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Original Report

Reconstruction of Sole of Foot: A Retrospective Study of 26 Consecutive Cases

***Dr.Kiran Petkar MS, MCh,* DNB**

Head, Dept of Plastic Surgery, Ananta Institute of Medical Sciences, Kaliwas. Rajsamand

Corresponding author: Dr Kiran Petkar, MS, MCh, DNB

Head, Dept of Plastic Surgery, Ananta Institute of Medical Sciences, Kaliwas. Rajsamand

Mailing address: Flat No.210, Manglam Residency ROSE, Navaratna Complex, Bhuwana, Udaipur, 313001, Rajasthan, India

Abstract: Loss of part or whole of foot is a distressing problem. The choice of reconstructive modality changes with advancement of science and hence, their long-term outcome is a matter of debate.
Materials and methods: consecutive cases of loss of part or whole of sole of over the preceding five years were studied. Patient profiles, etiology, nature of defects, reconstructive method used and the outcome were studied.
Results: A total of 26 limbs were treated for defects in sole of foot. Various modalities like adjacent flaps, pedicled flaps and free flaps were used to reconstruct various types of defects. The long-term outcome revealed weight-bearing and return of sensation in all patients. Return to workplace was at 53 days on average. Two cases of free muscle flap with split-skin grafting had repeated skin breakdown.
Discussion: reconstructive options for sole of foot are evolving. However, the principles and demand remain the same.
Conclusion: The reconstructive surgeon should be aware of the demands on the reconstructed sole and the various reconstructive modalities available. Treatment needs to be individualized to each patient. A continuous review of the cases and long-term results is necessary to enrich the science.

Key words: Sole of foot, sole reconstruction.

INTRODUCTION

Loss of sole of foot is not an infrequent occurrence. It can occur with trauma, pressure sore, surgical excision etc.[1] Reconstruction of sole of foot is a complex undertaking that needs to consider a multitude of factors. These factors include weight bearing, sensation, shear strength, attitude of joints, patient compliance, mobility etc. The trends in reconstruction keep evolving with changes in understanding of podiatry and newer reconstructive methods. It is hence imperative to keep assessing our methods and their results periodically. Studies evaluating different types of sole reconstruction are rare to find. This study tries to analyse the various reconstructive modes used for sole defects.

MATERIALS AND METHODS:

Consecutive cases of sole defects that the author treated in the past five years were analysed. Small defects that underwent successful direct closure were excluded. Patient profiles, etiology, nature of sole defects, reconstructive method used were studied. Outcome was assessed with respect to coverage, limb usage, durability of coverage, complications and donor site morbidity.

RESULTS:

A total of 26 cases of sole defects were managed by the author in the past five years. Patients' age ranged from 6 years to 72 years with mean age 32.4 years. 18 of them were males and 8 were females. Commonest etiology was trauma (n=20) followed by diabetic foot (n=4) and post-excisional (n=2). Size and location of the defect with respect to the foot and the depth are depicted in figures 1-4.

Reconstructive modalities used: Thorough debrima and wound toileting was done in each case before coverage was undertaken. All necrotic, devitalized and infected tissue was excised. In extensive cases, infection was allowed to subside by repeated dressings before posting the patient for sole reconstruction.

Twenty cases underwent flap reconstruction; four cases had split-skin grafting (SSG) and two cases were allowed to heal by secondary intention. SSG was used only on the insole.

Healing by secondary intention was allowed over the great toe and non-weight bearing area of heal. The various procedures used are tabulated in Table 1.

V-Y flaps were used in small defects (around 2cm) in fore-foot and mid-foot. Insole flaps were utilized in medium sized defects about 4-8cm in hindfoot (Fig 5). More extensive defects were covered with reverse sural artery (RSA) flap (Fig 6). One case that was referred with a failed RSA flap had to undergo a pedicled fasciocutaneous flap based distally on posterior tibial artery (Fig 7). These pedicled flaps from leg were used for defects over and around the heel. Four of the RSA flaps were delayed to increase the reach up to middle of the heel. Flap division and insetting was done at three weeks.Delay in division was employed in one case where flap approximation to wound surface was not satisfactory. Five of these pedicled flaps also helped cover tendo achiles. Besides, the posterior tibial artery flap also transferred a vascularised chunk of soleus musculotendinous segment for reconstruction of a ruptured and gaping Tendo Achiles.

Extensive defects over the entire or major part of sole with/without dorsum of foot were managed with free microvascular flaps (Fig 8, 9). The preferred flap was latissimus dorsi muscle flap with split-skin graft. In five cases, the anastomosis of flap vessels (thoracodorsal pedicle) was done to posterior tibial vessels and in one case anterior tibial vessels were used as recipients. Contralateral muscle was chosen in the former and ipsilateral flap was chosen for the latter for positional advantage. All arterial anastomoses were done end-to-side and venous anastomoses were done end-to-end. Heparin was used for five days and was then substituted by low-dose aspirin for three weeks. Entire span of the muscle was harvested but was inset after careful tailoring. Skin paddle was avoided to keep the surface uniform. Neurotisation was done by suturing the thoracodorsal nerve to the side of posterior tibial nerve in three cases.

In one case that was unfit for a free flap, cross-leg flap was done. Medial supramalleolar flap was put over the midfoot. The limbs were immobilized with external fixators. The flap was divided at three weeks.

Post-operatively, all limbs were given compression garments and microcellular rubber footwear. Silicone insoles were used in two cases. All patients including free flaps were encouraged gradual weight-bearing from three weeks post-operatively. Care of the foot was taught to all patients and their families. The patients were followed-up for at least two years.

OUTCOMES: All the limbs were salvaged. All the defects were covered. There was no mortality or major morbidity in any of the patients. Split-skin grafts for the defects and the donor sites healed with 100% take.

Two cases that were allowed to heal by secondary intention healed with contraction and fibrosis. The resultant depression at the edge of the sole and at the great toe respectively were given adequate padding and advised oil massage. The scars did not show breakdown at a follow-up of 3 years.

The insole flaps showed excellent pressure-bearing and tissue-match. However, fissure between the flap and the heel pad was noted in one patient for as long as six months. Donor site was always split-skin grafted and it healed well.

Pedicled flaps from leg healed very well after flap division. However, the flaps seemed bulky initially. But they shrunk with compression garments. The donor sites were split-skin grafted and healed well.

Cross-leg flap healed quietly. However, the patient developed grade 1 pressure-sore over sacrum and heel of the donor limb. The sore healed with nursing care.

Free flaps healed in ten to 15 days. There were no re-explorations. There was necrosis of the distal edge of the muscle in one patient. The resultant tissue loss healed by secondary intention in two weeks. There was donor site seroma in one case.

LONG-TERM OUTCOMES:

Weight-bearing and gait: At three months to four year follow-up, all the patients were walking on the reconstructed feet. Gait was disturbed in some due to associated orthopedic injuries. However, there was no hesitation from the patient to bear weight on the flap.

Durability of reconstruction: Two patients with lat dosri flap +SSG had ulceration over the weight-bearing area of the heel within one year. One of them subsided with wound care and repeat SSG with additional motivation on foot care and foot-wear. The other had repeated breakdowns. A lateral foot X-ray revealed a calcaneal spur at the site. The bony prominence was shaved off and the wound has healed with no further breakdowns for last two years.

Sensation: Sensation to pressure was present in all patients at three months follow-up. Sensation to light touch and pin-prick was absent in all pedicled and free flaps at the beginning. Smaller flaps had regained some sensation at six months and had developed good protective sensation at one year. Free flaps had some touch and pin-prick sensation developing at one year follow-up. The sensation and adaptability improved afterwards and patients were comfortable in managing their flaps at two years. The return of sensation did not vary conspicuously between those with neurotisation and those without. Actually, the two cases with skin-graft breakdown over heel had had neurotisation done by suturing thoracodorsal nerve to the posterior tibial nerve. Their graft loss was attributed to improper foot-care and bony prominence respectively.

Return to workplace: Time until return to workplace ranged from four weeks to ten months after foot surgery. Average was 53days. Delays for several months were mainly due to ongoing orthopedic and/or neurosurgical treatment and rehabilitation in polytrauma cases.

DISCUSSION:

Loss of sole of foot is a debilitating problem for various reasons. The glabrous skin of sole is unique. The capacity to

bear weight, sensation, shear strength and fatty cushioning makes this tissue irreplaceable. The importance of this structure is reflected in the fact that, loss of sole or even the loss of sensation in sole tilts the plan of management towards amputation in several limb salvage indices.[2] Hence, it is just not sufficient to cover the defect or heal the wound. The reconstructed sole needs to perform all the specialized functions of the sole with as much perfection as the sole itself. Most important of them are:

1. Immediate and permanent coverage to protect the underlying structures including bones, joints, ligaments and tendons. Failing this, the structures get infected, desiccated, and week. This might cause long-term disturbances in structure (plantar arches), functions, and healing. Being uncovered for longer duration might also causes chronic infection and sinuses.
2. Sensation. Sensation in the sole is imperative without which, there can be repeated trauma, ulceration and infections.
3. Durability. The cover needs to be durable.
4. Shear strength. The cover has to bear a lot of shearing forces and not yield to it or break down.
5. Right thickness. The coverage should neither be too bulky nor be too thin.
6. Tightness. The neo-sole should not wobble on subjected to weight. Normally, the tight fibrous septae of the sole keep the skin held tightly to the skeleton. The reconstructed sole need to mimic this property.

Due to so many demands on the sole reconstruction, it becomes a very tricky and difficult endeavour to carry out. Several reconstructive options have been advocated depending on the site and nature of the defect. Initially it was only the local flaps, skin grafts, cross-leg flaps or tubed-pedicle flaps that were applied as waltzing flaps. With advent of newer flaps and microsurgical techniques, the trends of reconstruction have changed. However, the goals and principles of reconstruction have remained the same.

In the present paper, the author has attempted to compile his experience in sole reconstruction over the years. The highlight of the study is that, various reconstructive techniques mentioned along the reconstructive ladder have been applied. Starting from allowing healing by secondary intention to microsurgical reconstruction, entire spectrum of plastic surgeon's armamentarium has been put to use to get the best possible result in every patient. The author feels that treatment plan needs to be individualized depending upon the tissue, the limb, the patient as a whole and also the patient's family and surroundings.

Split-skin graft is all that is required in non-weight bearing areas. This fact is vouched by the very donor site of insole flaps that are surgically created. However, it is important to map the weight-bearing areas preoperatively.

Although the smaller defects that could be closed directly were excluded from the study, the cases that were intentionally left for healing by secondary intention were included intentionally. Defects such as at the edge of the sole or on the underside of great toe can be left to heal on their own. It is important to visualize in fourth dimension (Time!). The end result at the edge of the sole is a scar that pulls the glabrous skin to create aesthetically unpleasant dimple but one that won't trouble weight-bearing or the durability. Similarly at the great toe. It is to be remembered that, ulceration causes the wound to gape and appear bigger that the actual 'defect' per se. These scars are to be properly cared for for the rest of life.

Insole flaps are of various types: based on medial plantar artery, its perforators, with abductor hallucis or without, with innervations intact or without. In general they are sturdy and simple flaps with immediate or early return of sensation[3]. They were used in our study for mainly middle or anterior aspect of heel.

Various pedicled flaps have been studied in sole reconstruction in comparison with free flaps.[4, 5] However, one has not claimed superiority over the other as far as the final results are concerned. The author finds the same. It is the extent of reconstruction that decides if pedicled flaps are sufficient or a free flap is required. The author makes the choice based on this factor and the general condition of the patient in each case. However, it is to be noted that free flaps are larger undertakings in Indian medical practice and are called for when simpler measures are not adequate.

One perceived advantage of free flaps in sole reconstruction was the opportunity to neurotise the flap. However, we did not notice much difference after neurotising the muscle flap. Similar findings were noted by authors of larger studies.[6] it is also notable that, the sensation in the plantar foot as a deciding factor for attempts at limb salvage are being questioned by well-performed studies and newer limb salvage indices[7.] This is probably due to improvement in allied technologies like orthotics and podiatry. However, these changes also demand a proper after care of the foot.

The study in general reviews the various modalities used in sole reconstruction and emphasizes that the treatment plan be individualized to every limb and every patient.

Procedure	No. of cases	%
Split-skin graft	4	15.4%
Healing by secondary intention	2	7.7%
V-Y advancement flap	2	7.7%
Insole flap	3	11.5%
Reverse sural artery flap	7	26.9%
Posterior tibial artery flap	1	3.9%
Cross-leg flap	1	3.9%
Free Lat Dorsi muscle flap	6	23.1%

Table 1. Reconstructive procedures

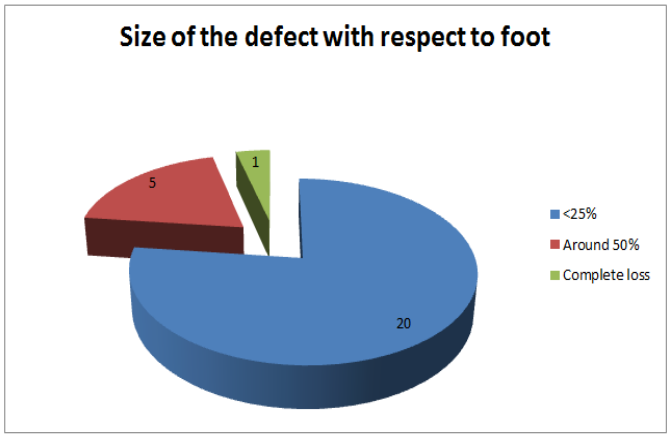

Fig 1. Size of the defect with respect to sole surface area

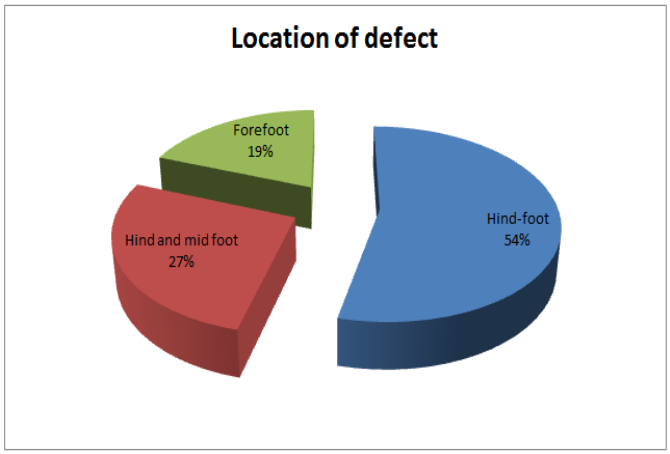

Fig 2, Location of defect

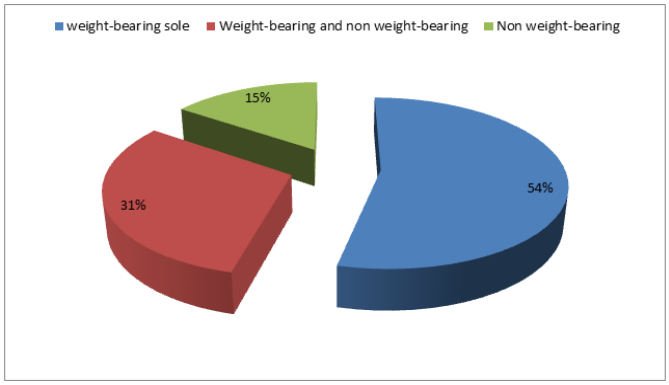

Fig 3. Weight-bearing

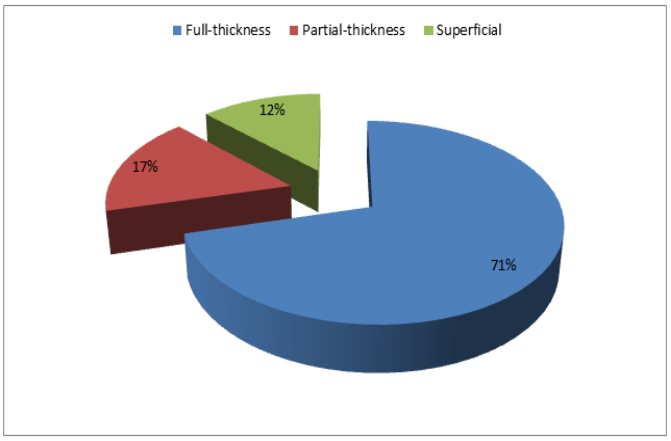

Fig 4. Defect thickness

Fig 5. Insole flap

Fig 6. Reverse Sural Artery (RSA) Flap

Fig 7. Posterior Tibial Artery Flap

Fig 8. Extensive loss of sole

Fig 9. Defect in fig 8 reconstructed with free Lat Dorsi Flap

CONCLUSION:

Reconstruction of sole of foot is a complex undertaking. The reconstructive surgeon should be aware of the demands on the reconstructed sole and the various modalities available. The treatment needs to be individualized to each patient. A continuous review of the cases and long-term results is necessary to enrich the science and art of sole reconstruction.

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